SMTF at Fermilab

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Phase I

a) Single TESLA cryomodule test

Phase II

a) Single cryomodule Photoinjector beamline
b) Four cryomodule Photoinjector beamline

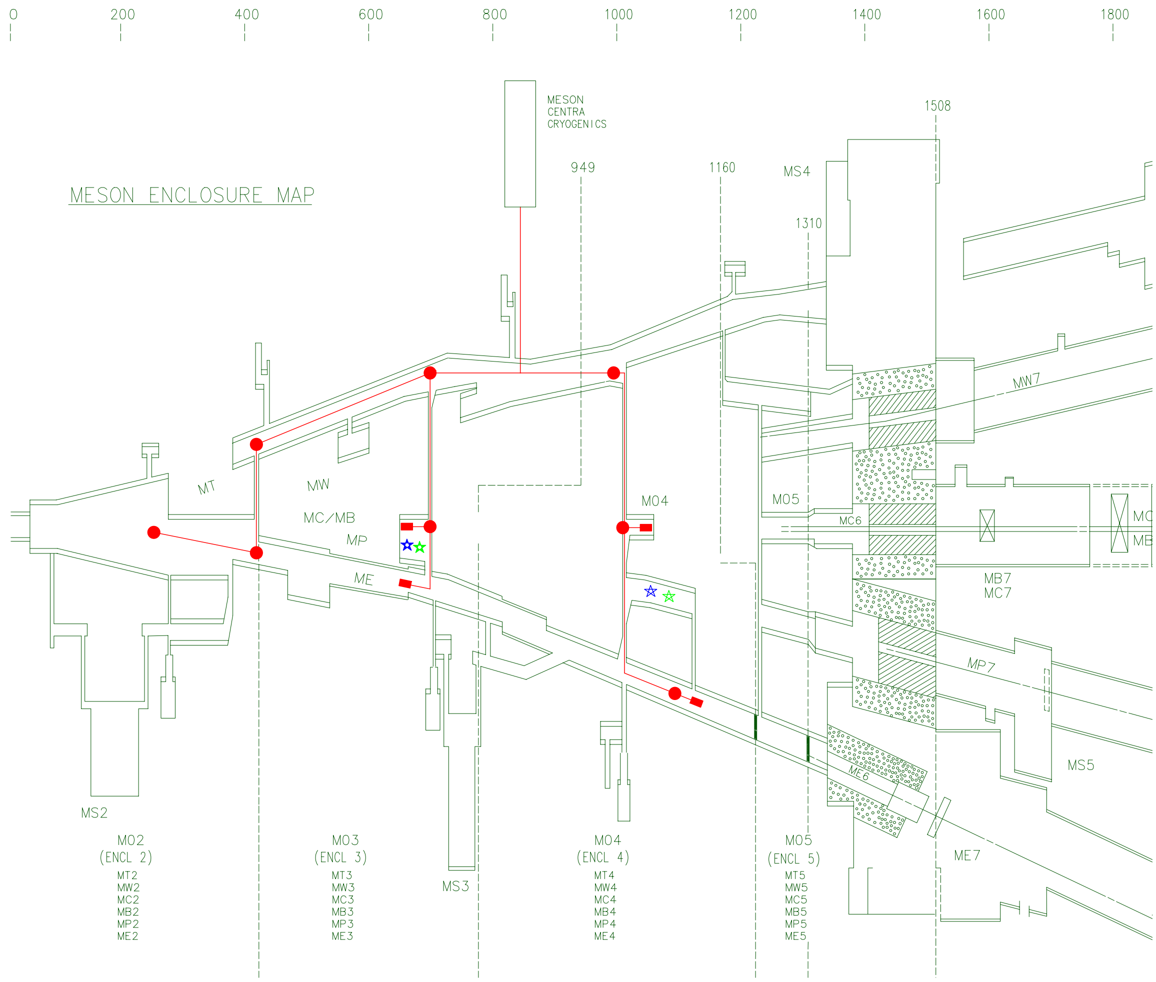

Figure 1 Meson Enclosure Map and Cryogenic Transfer Line Location

MESON AREA

The Meson beamline enclosures are shown in Figure 1. Currently Meson enclosure is used for Meson Test Beam Facility (MTBF) and E907. The MTBF is located in the M_{Test} beamline and E907 in the M_{Center} beamline. MTBF enables experimenters who are planning experiments to test their detectors in an active beamline and also permits detectors for other types of research (cosmic rays, etc.) to be calibrated. E907 –The Main Injector Particle Production (MIPP) Experiment will measure the production of particles by the 120 GeV Main Injector proton beam for the NuMI project targeting.

CRYOGENICS

Cryogenic Test Facility (CTF), formerly the Meson Central Cryogenics (MCC), located on the west side of the Meson beamline, can provide cryogenics for a cryomodule test. CTF houses three (3) Tevatron satellite refrigerators capable of producing a total of 1,500 W at 4.5K. Cryogenic transfer line from the CTF is available in M02, M03 and M04 enclosures, formerly servicing superconducting bending magnets in various portions of the East, Center and West beamlines. For Phase 2b, a new cryogenic plant is required. Design, construction, installation and commissioning of a new refrigerator will require a minimum of two years from the point the contract is let. Emphasis will be placed on establishing 4.5K helium and LN_2 from the CTF to the Meson Detector Building (MDB) for use in a single cryomodule test utilizing a vacuum pumping system to achieve superfluid helium.

In order to satisfy a remote superfluid helium load, the CTF refrigerators will be operating in a liquefier mode. Operation in this mode is inherently less reliable. It is more demanding on expander and heat exchanger performance. Helium impurity degrades the expander and heat exchanger performance, thus is detrimental to the reliability and capacity of the system.

The transfer line and header connections to the refrigeration system have been removed in order to perform cryogenic testing within CTF while maintaining the Meson enclosures ODH Class 0. In order to reactivate the transfer line, a new bayonet can would have to be designed and built. There is a known design flaw in some of the expansion cans used in the Meson transfer line system. Prior to reactivating the transfer line, all expansion cans of this type would need to be checked and repaired. Transfer line, helium and nitrogen suction header extensions currently leading to M02 and M03 will be isolated from the rest of the tunnel system.

The transfer line in M_{East} will need to be extended about 300’ from ME4 to MDB. An appropriate transfer line expansion box will need to be installed in the extension. The existing ME4 bayonet can would be moved to the MDB. The helium and nitrogen suction headers will need to be extended by the same distance. When this work is completed, it will enable 4.5K helium and 80K nitrogen to be delivered to the MDB.

Part of the 4.5K stream will be used in the production of superfluid helium. The remainder of the 4.5K flow will be used to satisfy 5-8K heat shield loads in the cryomodules and to maintain stability in the CTF/MDB cryogenic transfer line. For convenience, the 40-80K shield loads in the cryomodules will be cooled using 80K LN_2. From this point, cryogens can be distributed to SCRF test area(s).

Distribution of cryogens within a test cave will require a bayonet can, transfer line, feed can and end cap. Low pressure helium from the cryomodule will be warmed to room temperature in a header leading to the vacuum pumping system. It is imperative that the subatmospheric portion of the system remains leak tight for reliable cryogenic system operation. The vacuum pumping system requires an oil removal system to ensure the prevention of oil migration. Care will need to be taken to ensure that inherent vibration of the positive displacement vacuum pumps will be isolated in order to not impact SCRF performance.

The control system used at MCC during the last Fixed Target run was removed for a cryogenic controls upgrade at CDF. Since then, new controls have been installed and the system is now operational. The facility is currently being operated for various Tevatron cold compressor tests related to Collider Run II maintenance and reliability. Future test plans include a versatile test cryostat to investigate hydrodynamic and thermal properties of single and two phase He I and He II. To perform tests in He II, a small vacuum pumping system has been installed capable of cooling loads of about 10 watts down to 1.8 K.

A new local distributed cryogenic controls system is required to operate the cryogenic distribution and vacuum pumping systems. This controls system must be integrated to the existing CTF refrigerator controls system. Cryogenic instrumentation required for the distribution, vacuum pumping and cryomodule systems will feed into this controls system.

HEAT LOAD

Heat load of a single 9 cell TESLA cryomodules with a quad at E = 23.4 MV/m , Q = 1x 10^{10} and 5 Hz rep rate is presented in the Table 1 below.

Table 1 TESLA 8 Cavity Cryomodule Heat Load Estimate (courtesy S. Wolff)

	E_{acc} [MV/m]		Q		Rep Rate [Hz]	
	23.4		1.00E+10		5	
TESLA 9 cell module w/ Quad	2K load [W]		5/8 K load, [W]		40/80 K load, [W]	
	static	dynamic	static	dynamic	static	dynamic
RF load	-	4.95	-	-	-	-
Radiation	-	-	1.95	-	44.99	-
Supports	0.60	-	2.40	-	6.00	-
Input coupler	0.76	0.14	2.05	1.19	21.48	59.40
HOM coupler (cable)	0.01	0.27	0.40	2.66	2.55	13.22
HOM absorber	0.14	0.02	3.13	0.77	- 3.27	15.27
Beam tube bellows (12)	-	0.24	-	-	-	-
Current leads	0.10	0.01	-	-	13.00	5.00
HOM to structure	-	1.68	-	-	-	-
Coax cable (4)	0.01	-	0.03	-	0.08	-
Instrumentation taps	0.05	-	0.54	-	2.82	-
Diagnostic cable	0.07	-	0.82	-	2.48	-
Subtotal	1.74	7.31	11.32	4.62	90.13	92.89
Total	**9**		**16**		**183**	

It is desirable to operate the TESLA cryomodules with a gradient of 35 MV/m in the SMTF. This adds considerably to the dynamic heat load. A summary of a first pass estimated heat load at the three temperature levels for Phase 1, 2 and 3 at 5 Hz repetition rate are given in Table 2. Cavity RF loads were scaled from the TESLA Technical Design Report by the cavity Q, RF pulse length and square of the gradient ratios. TESLA TDR and A0 operating experience is used for the static heat load estimates. Further detailed understanding of other dynamic loads within the cryomodule is warranted. For the purpose of this study, an uncertainty factor of 1.3 is used to compensate unknown loads.

The loads presented in Table 2 define the applicability of CTF as Phase 1 and 2. A new cryogenic system is required to support Phase 3 and beyond of the program at 5 Hz.

Table 2 Phased SMTF Heat Load Estimates

Phase 1

Item	Qty [# or ft]	Heat Load 2K	Heat Load 5K	Heat Load 80K
TESLA Cryomodule	1	19	17	236
End cans	2	2		
A0 9-cell cavity	0	0	0	0
High Gradient 9 cell cavity	0	0	0	0
3rd Harmonic	0	0	0	0
Tunnel transfer line	1500		23	91
Feedbox & TRL	30	2	6	75
Total Estimated		24	46	402
Uncertanty Factor		1.3	1.3	1.3
Capacity Required		**31**	**59**	**523**

Phase 2

Item	Qty [# or ft]	Heat Load 2K	Heat Load 5K	Heat Load 80K
TESLA Cryomodule	2	39	34	471
End cans	2	2		
A0 9-cell cavity	1	5	8	47
High Gradient 9 cell cavity	1	8	9	61
3rd Harmonic	1	6	9	61
Tunnel transfer line	1500		23	91
Feedbox & TRL	60	2	12	150
Total Estimated		62	95	881
Uncertanty Factor		1.3	1.3	1.3
Capacity Required		**81**	**123**	**1146**

Phase 3

Item	Qty [# or ft]	Heat Load 2K	Heat Load 5K	Heat Load 80K
TESLA Cryomodule	4	77	67	942
End cans	2	2		
A0 9-cell cavity	1	5	8	47
High Gradient 9 cell cavity	1	8	9	61
3rd Harmonic	1	6	9	61
Tunnel transfer line	1500		23	91
Feedbox & TRL	60	2	12	150
Total Estimated		101	128	1353
Uncertanty Factor		1.3	1.3	1.3
Capacity Required		**131**	**167**	**1758**